SPACECRAFT INTERNAL ACOUSTIC ENVIRONMENT MODELING

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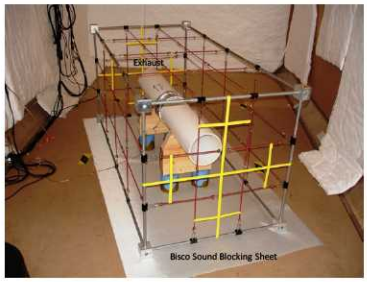
ABSTRACT
Acoustic modeling can be used to identify key noise sources, determine/analyze sub-allocated requirements, keep track of the accumulation of minor noise sources, and to predict vehicle noise levels at various stages in vehicle development, first with estimates of noise sources, later with experimental data. In FY09, the physical mockup developed in FY08, with interior geometric shape similar to Orion CM (Crew Module) IML (Interior Mode Line), was used to validate SEA (Statistical Energy Analysis) acoustic model development with realistic ventilation fan sources. The sound power levels of these sources were unknown a priori, as opposed to previous studies that RSS (Reference Sound Source) with known sound power level was used.

The modeling results were evaluated based on comparisons to measurements of sound pressure levels over a wide frequency range, including the frequency range where SEA gives good results. Sound intensity measurement was performed over a rectangular-shaped grid system enclosing the ventilation fan source. Sound intensities were measured at the top, front, back, right, and left surfaces of the grid system. Sound intensity at the bottom surface was not measured, but sound blocking material was placed under the bottom surface to reflect most of the incident sound energy back to the remaining measured surfaces. Integrating measured sound intensities over measured surfaces renders estimated sound power of the source. The reverberation time T_{60} of the mockup interior had been modified to match reverberation levels of ISS US Lab interior for speech frequency bands, i.e., 0.5k, 1k, 2k, 4 kHz, by attaching appropriately sized Thinsulate sound absorption material to the interior wall of the mockup. Sound absorption of Thinsulate was modeled in three methods: Sabine equation with measured mockup interior reverberation time T_{60}, layup model based on past impedance tube testing, and layup model plus air absorption correction. The evaluation/validation was carried out by acquiring octave band microphone data simultaneously at ten fixed locations throughout the mockup. SPLs (Sound Pressure Levels) predicted by our SEA model match well with measurements for our CM mockup, with a more complicated shape.

Additionally in FY09, background NC noise (Noise Criterion) simulation and MRT (Modified Rhyme Test) were developed and performed in the mockup to determine the maximum noise level in CM habitable volume for fair crew voice communications. Numerous demonstrations of simulated noise environment in the mockup and associated SIL (Speech Interference Level) via MRT were performed for various communities, including members from NASA and Orion prime-/sub-contractors. Also, a new HSIR (Human-Systems Integration Requirement) for limiting pre- and post-landing SIL was proposed.

Also, mockup fidelity will be increased as an ECLSS wall made of sandwich panels will be installed inside the mockup. The material of the sandwich panel was selected for having acoustic transmission loss similar to the real ECLSS wall panels inside the Orion vehicle.



Sound Intensity Measurement

Sound Intensity Mapping